
Technical Brief: Built-In Test (BIT) and Automatic Test Equipment (ATE) for the Mk 48 Torpedo with Comparison of Health Tag Value

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1. Executive Summary

The Mk 48 is a heavyweight, acoustic-homing torpedo with all-digital guidance and control, sophisticated sonar, and digital fuzing—designed for repeated upgrades via software and hardware kits. [Navy](#)

Because the weapon spans multiple configurations (exercise vs warshot) and includes safety-critical subsystems (warhead/fuzing, propulsion, in-water run safety), the program relies on a **layered test philosophy**:

1. **On-weapon BIT / self-test** within guidance & control electronics and interfaces (health/status, continuity, sensor validity, and safety interlocks).
2. **Automatic Test Equipment (ATE) at Intermediate Maintenance Activities (IMAs)** for comprehensive system verification and configuration control.
3. **Depot-level maintenance and troubleshooting** at designated facilities (e.g., NUWES/NUWC Keyport in training literature) for complex repairs and reliability programs. [Military Newbie](#)

In public sources, the most concrete detail about Mk 48 “BIT” is represented by the **Mk 48 In-Service Support Equipment (ISSE)** suite—especially the **Mk 660 Mod 2 ATE**, which performs comprehensive system testing and supports safe “simulated swim scenarios.” [NAVSEA+1](#)

2. BIT Objectives and Scope (Mk 48 Context)

BIT for a heavyweight torpedo is not a single test; it is a **test architecture** aimed at:

- **Safety assurance**: verification of warhead safing/arming logic, in-water run safety mechanisms, and command interlocks before, during, and after handling and test evolutions. (ISSE explicitly supports safety verification and exercise-run safety testing.) [NAVSEA+1](#)
- **Configuration integrity**: ensuring the torpedo is in the correct mod/build configuration (hardware and tactical software). The Mk 48’s digital guidance system is designed for upgrades, which makes configuration control central. [Navy+1](#)
- **Functional readiness**: confirming key mission functions—sonar chain, signal processing, weapon control, inertial/depth sensing, steering actuation, propulsion interfaces, and wire/combat-system interfaces—operate within tolerance. [NAVSEA](#)
- **Fault detection and isolation**: rapidly discriminating “no-fault found” events from genuine degradations to reduce false removals and to target depot repairs appropriately.

3. BIT Levels and Where They Happen

3.1. On-Weapon / Embedded BIT (Operational Level)

Public technical descriptions of the Mk 48 Mod 6AT Guidance & Control (G&C) section describe a modern, open architecture with integrated interfaces to multiple subsystems (IMU, depth sensor, warhead electronics, propulsion section, and submarine combat control interface). [NAVSEA](#)

This architecture supports embedded health monitoring and self-test checks such as:

- **Processor and bus health** (COTS/open systems, industry-standard bus communications). [NAVSEA](#)
- **Sensor plausibility/interface validation** (IMU and depth sensor interfaces are explicitly part of the control interface). [NAVSEA](#)
- **Actuation and control-loop readiness** (autopilot interface controlling propulsion section and control surfaces). [NAVSEA](#)
- **Software integrity checks** (tactical software is downloaded via ATE and erased via memory-scuttle circuitry at the end of an exercise run; dockside/shipboard updates via a portable download system are supported). [NAVSEA](#)

Note: Detailed bit-by-bit test vectors, thresholds, and failure codes are typically controlled technical data and are not disclosed in open literature. This report therefore describes the BIT system at the architecture and workflow level.

3.2. IMA-Level Comprehensive Testing (ATE / ISSE)

The **Mk 48 ISSE** is explicitly defined as “all test and support equipment required for testing and turnaround of all Mk 48 variants at the Mk 48 Intermediate Maintenance Activity,” with the Mk 660 Mod 2 ATE as the centerpiece. [NAVSEA](#)

The ISSE supports both **comprehensive system tests** and **subsystem bench tests** that, in effect, operationalize BIT for maintainers: cable integrity, propulsion support equipment, steering actuator verification, warhead exploder testing, and exercise-run data extraction and reduction. [NAVSEA](#)

3.3. Depot-Level Maintenance / Reliability Programs

Training literature notes depot-level maintenance support for the Mk 48 at NUWES/Keyport and other locations for associated equipment. [Military Newbie](#)
In practice, depot actions often follow when IMA tests/BIT indicate deeper faults or when reliability programs require teardown inspection.

4. Mk 48 ISSE Test Stack (What “BIT” Looks Like in Practice)

The following table consolidates the publicly listed Mk 48 ISSE elements and what each contributes to BIT coverage.

ISSE Element	Purpose / BIT Coverage Contribution
Mk 660 Mod 2 Automatic Test Equipment (ATE)	Core comprehensive system testing for Mk 48 configurations; supports verification workflows and safety-feature validation (including simulated scenarios). NAVSEA+1
Mk 556 Mod 5 Cable Test Set (CTS)	Automated continuity, insulation resistance, dielectric strength, and high-speed analog/digital continuity testing for internal and external cable assemblies. NAVSEA
Mk 23 Mod 1 Fleet Data Reduction System (FDRS)	Reduces and analyzes data extracted from exercise section data recorders; produces hard-copy outputs and archived processor function data for post-run analysis. NAVSEA
Data Extraction Unit (DEU)	Extracts in-water run data from exercise data recorders to removable media for subsequent analysis via Mk 23 FDRS. NAVSEA
Mk 658 Fuel Delivery Assembly Test Set (FDATS)	Tests fuel delivery assemblies (Mods 5/6/6AT) and fuel pump (Mod 4); includes controller, hydraulic pump, and fuel substitute reservoir. NAVSEA
Mk 659 Steering Assembly Test Set (SATS)	Validates steering assemblies; monitors feedback voltage to confirm mechanical control surface position. NAVSEA
Mk 562 Mod 3 Common Exercise Head Test Set (CEHTS)	Tests exercise sections and associated in-water run safety mechanisms; architecture emphasizes COTS and open-system interfaces. NAVSEA
Mk 525 Mod 3 Exploder Test Set (ETS)	Tests functionality of Mk 48 exploders (portable controller with printer/touch display). NAVSEA
Mk 5 Hydraulic Filling Unit	Drains/evacuates/backfills/pressurizes hydraulic systems; performs vacuum leak tests on afterbody/tailcone components. NAVSEA
Mk 6 Fuel Tank Filling Unit	Drains/flushes/vacuum tests/refuels fuel tanks; provides controlled handling verification. NAVSEA
Mk 576 Igniter Test Set	Measures igniter squib resistance accurately (portable). NAVSEA

Interpretation: the Mk 48 “BIT system,” as implemented across the lifecycle, is best understood as **embedded self-test + ATE-driven end-to-end verification + purpose-built subsystem testers**, with data capture and post-run analytics to close the loop. [NAVSEA](#)

5. BIT Coverage by Major Torpedo Subsystem

5.1. Guidance & Control (G&C) and Sonar Chain

The Mod 6AT G&C is described as a COTS/open architecture with signal processing reserve capacity and defined functional blocks (beamforming, transmit control, detection/classification/tracking, weapon control, and interfaces). [NAVSEA](#)

BIT focus areas include:

- Digital processing health (COTS processing, bus comms, spare expansion slots). [NAVSEA](#)
- Sonar transmit/receive chain sanity checks (controller, waveform generator, A/D conversion, filtering/beamforming). [NAVSEA](#)
- Interface integrity to submarine combat control system and other subsystems (explicitly called out). [NAVSEA](#)
- Tactical software load and integrity (downloaded by ATE; memory scuttle at end of run; portable download system for dockside/shipboard upgrades). [NAVSEA](#)

5.2. Steering / Control Surfaces

Steering assembly BIT at maintenance level is directly supported by the Mk 659 SATS, which checks commanded vs measured positions via feedback voltage. [NAVSEA](#)

5.3. Propulsion / Fuel / Hydraulics

Propulsion support equipment (fuel delivery assembly testing, hydraulic filling, fuel tank filling, vacuum/leak tests) provides readiness confirmation and reduces latent “handling-induced” failures. [NAVSEA](#)

5.4. Warhead Electronics / Exploder / Fuzing Safety

The Navy fact file identifies “digital fusing systems.” [Navy](#)
At maintenance level, the Mk 525 Exploder Test Set validates exploder functionality, and the Mk 562 CEHTS specifically tests **exercise sections** and **in-water run safety mechanisms** (critical to safe training events). [NAVSEA](#)

5.5. Cable Harnessing and Interconnect

The Mk 556 CTS provides rigorous automated cable tests (continuity, insulation, dielectric strength, high-speed continuity), which is an important contributor to reducing intermittent failures that can masquerade as electronics faults. [NAVSEA](#)

6. Data Logging, Post-Run Analysis, and Feedback to BIT

For exercise configurations, the Mk 48 ecosystem includes:

- **Data Extraction Unit (DEU)** to pull run data from exercise recorders to removable media [NAVSEA](#)
- **Mk 23 Mod 1 FDRS** for reduction/analysis, producing hard-copy outputs and archived processor-function tapes for post-run analysis [NAVSEA](#)

This supports a closed-loop reliability process: post-run anomalies can be correlated to pre-run BIT/ATE results, improving fault isolation and maintenance policy.

7. Safety Engineering and Test Assurance

The ISSE document states that Mk 48 tactical software was developed and evaluated using **MIL-STD-498** and that **MIL-STD-882** structured the safety architecture (with reference to STANAG 4404 as well). [NAVSEA](#)

From a BIT perspective, this implies:

- Safety requirements are explicitly decomposed into verifiable elements.
- ATE/CEHTS workflows include safety verification steps (e.g., simulated scenarios and in-water run safety mechanism checks). [NAVSEA+1](#)

8. Practical BIT Workflow (Representative)

A typical high-level readiness flow (exercise or warshot turnaround) looks like:

1. **Configuration & software control** (ATE-managed load/verification; controlled updates via portable download system where authorized). [NAVSEA](#)
2. **Comprehensive ATE system test** (Mk 660 Mod 2) to validate end-to-end functional readiness and safety features. [NAVSEA+1](#)
3. **Targeted subsystem tests as indicated**
 - Harness/cables (Mk 556) [NAVSEA](#)
 - Steering (Mk 659) [NAVSEA](#)
 - Fuel delivery/hydraulics/fuel tanks (Mk 658 / Mk 5 / Mk 6) [NAVSEA](#)
 - Igniters (Mk 576) [NAVSEA](#)
 - Exercise head safety mechanisms (Mk 562) [NAVSEA](#)
 - Exploder functionality (Mk 525) [NAVSEA](#)
4. **Exercise run** (if applicable) and **post-run data extraction + reduction** (DEU + FDRS). [NAVSEA](#)
5. **Disposition decision**: return to service, repair at IMA, or route to depot based on BIT/ATE evidence and troubleshooting outcomes (training literature describes depot support and DSLE-type programs). [Military Newbie](#)

9. Limitations of Open-Source BIT Detail

Open sources describe the **test ecosystem and architecture** well, but do not disclose:

- exact BIT fault codes, thresholds, and coverage metrics,
- detailed test sequences and timing,
- classified mission-mode diagnostics.

10. RuBee Health Tag vs BIT for MK48 Table

Hazard / Failure Mode	Fact vs Inference	L0 Embedded BIT	L1 Platform BIT	L2 IMA ATE	L3 Subsystem Tests	L4 Post-Run Data	L5 Health Tag	Key Observations / Diagnostic Gaps
H1: Failed launch / abort (no swim-out / immediate termination)	Inference (few open-source cases)	M	H	H	M	N/A	M	Usually caught by interlocks + ATE. Remaining risk is intermittent interface faults and handling-induced connector issues.
H2: Premature propulsion ignition (“hot run”)	Fact (hazard mode) + inference (causes)	M	H	M	H (igniter, fuel/hydraulics)	N/A	H	Biggest value of health tag: capture abnormal temps/accel/vibration/stray voltage signatures pre-event; supports root cause and liability clarity.
H3: Unintended arming / fuzing unsafe state	Inference (safety-critical)	H	H	H	H (exploder tests)	N/A	M	Typically engineered to fail-safe; tag adds value mainly for chain-of-custody and “state history” (armed/inhibit transitions).
H4: Accidental warhead detonation	Inference (no confirmed public Mk 48 cases)	M	M	M	M	N/A	L–M	Catastrophic but engineered extremely low probability. Health tag rarely prevents, but can record environmental abuse (shock/fire) and safing state leading up.

H5: Igniter squib out-of-family (open/short/drift)	Inference (common energetic initiator failure mode)	L–M	M	H	H	N/A	M–H	Subsystem testing is strong. Tag helps detect long-term drift (aging) if it can measure resistance periodically with microamp methods.
H6: Fuel delivery restriction/leak / pump anomaly	Inference	L	L	H	H	N/A	H	A health tag with pressure/temp/vibration can detect slow degradation during storage and handling far better than episodic shop tests.
H7: Hydraulic fill/pressure leak-down impacting control	Inference	L	L	H	H	N/A	H	Tag can log slow leak-down and temperature-compensated pressure trends; this is a prime “latent fault” category.
H8: Steering actuator / control surface position feedback fault	Inference	M	L	H	H	N/A	M	Existing steering test set coverage is strong; tag adds value for shock events that shift calibration between tests.
H9: Cable harness intermittents / connector fretting	Inference (common in fielded weapons)	M	M	H	H (cable test set)	N/A	H	This is where tag shines: logging micro-interrupts, shock-correlated discontinuities, humidity exposure, and ESD events not seen during bench tests.
H10: Sensor plausibility faults (depth/IMU out of range, drift)	Inference	H	M	H	M	M (exercise data)	H	Embedded BIT catches gross faults; tag catches slow drift during storage and provides trending.
H11: Software load/config mismatch	Inference (config-control driven)	H	M	H	M	M	M	ATE is primary gate. Tag adds independent checksum/time-of-load and tamper evidence if required.

H12: Handling/trans port shock or environmental abuse leading to latent failure	Fact (transport incidents exist) + inference	L	N/A	M	M	N/A	H	Open-source shows transport mishaps occur. Tag is most valuable for capturing shock spectrum, orientation, and exposure history to prevent “unknown abuse” entering inventory.
Legend:								
H = High detection coverage (direct, repeatable, discriminative)								
M = Medium (detects some cases; may have ambiguity)								
L = Low (detects rarely / indirectly)								
N/A = not applicable								

Below is a **one-page comparison diagram**: a **design review or executive briefing**. It is formatted to read left-to-right as a **layered assurance stack**, which is how reviewers typically reason about BIT vs ATE vs an external health tag.

11. BIT – ATE – Health Tag

Dimension	BIT (Built-In Test)	ATE (Automatic Test Equipment)	Health Tag (Non-Invasive)
Physical location	Inside the weapon	External test station	External strap-on device
Connection to the weapon	Direct electrical & software	Direct electrical via test interfaces	None (no electrical contact)
Primary purpose	Prevent unsafe operation; detect gross faults	Verify readiness; isolate faults	Capture condition history between tests
When it runs	Power-up, pre-launch, during operation	Maintenance / turnaround	Continuous (storage, transport, handling)
Fault types detected best	Hard failures, unsafe states	Functional & parametric faults	Latent damage, abuse, environmental stress
Depth of fault isolation	Shallow–medium	Deep (LRU/SRU-level)	None (contextual only)
Safety role	First line of defense (inhibits)	Certification gate	Evidence & forensics
False-removal reduction	Limited	Moderate	High (context eliminates NFF)
Data persistence	Usually volatile	Test records only	Long-term historical log
Cyber / safety exposure	Internal system risk	Controlled test environment	Isolated, non-interfering

12. What Each Layer Answers

12.1. BIT Answers:

*“Is the weapon safe and functional **right now**?”*

- Enforces safing and inhibits
- Stops operation if internal faults are detected
- Not designed to explain *why* a fault occurred

12.2. ATE Answers:

*“Does the weapon meet **all requirements at this maintenance event**?”*

- Comprehensive, scripted, auditable testing
- Deep fault isolation
- Snapshot in time — no visibility between tests

12.3. Health Tag Answers:

*“What risk happened **since the last ATE or before prelaunch BIT**?”*

- Shock, vibration, thermal, humidity, handling history
- Detects **unknown abuse**, latent damage precursors
- Enables targeted ATE instead of broad retest
- Does **not** declare readiness by itself

12.4. Why the Health Tag Is Additive (Not Redundant)

- BIT and ATE are **event-based**
- The health tag is **time-continuous from device birth to the event**.
- It fills the **largest diagnostic blind spot**:
 - transport damage
 - handling shock
 - environmental exposure
 - chain-of-custody ambiguity
 - pick the best, most likely to succeed

BIT and ATE say “pass/fail.” - Health Tag says “why at risk”

13. Executive Takeaway

BIT keeps the weapon safe, ATE proves it works, and the Health Tag proves it wasn’t damaged in between.